HAMMER THROW WR PHOTOSEQUENCE - YURIY SEDYKH

By Ralph Otto. Photosequence by Gabriele Hommel (© Hommel AVS 1992)

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The sequence shows his fourth attempt at the 1986 European Championships in Stuttgart, which set a new World Record of 86.74m.

- Yuriy Sedykh (RUS)
    - Born: 11 June 1955
    - Height: 1.85m
    - Weight: 110kg
    - Olympic Champion 1976 and 1980; European Champion 1978, 1982, and 1986; six World Records and two World Junior Records.

I Introduction

This sequence shows the current World Record in the Hammer Throw of 86.74m set by Yuriy Sedykh at the 1986 European Championships in Stuttgart. In addition to the photos of this sequence, his throw was filmed with two high-speed cameras with a rate of 200 frames per second. After this, his throw was submitted to a three-dimensional kinematic analysis. The results of this analysis are the basis of the following study of movement.

The comparison of Sedykh's technique with that of other athletes is possible on the basis of 77 throws by international level hammer throwers analyzed between 1985 and 1990 at the Institute for Athletics and Gymnastics of the German University for Sports in Cologne.

2 Movement structure

Sedykh's hammer throwing action can be divided into the following phases:

- Two preliminary swings up to the low point of the hammer orbit prior to the first turn;
- Three turns each including one double and one single support phase;
- Release phase.

Because of slight variations between athletes during the execution of the preliminary swings, our analysis starts only at the low point of the hammer orbit prior to the first turn (photo 6) and ends with the hammer leaving the left hand (photo 49). Within this evaluated movement phase the following characteristic temporal points of the throw can be identified and defined:

t0 moment of reaching the minimal height of the hammer head prior to the first turn (low point of the hammer) — photo 6

- t1: moment of the last ground contact of the right foot (first lifting) — photo 11
- t2: moment of the first ground contact of the right foot (first ground contact) — photo 18
- t3: moment of the last ground contact of the right foot (second lifting) — photo 25
- t4: moment of the first ground contact of the right foot (second ground contact) — photo 31
- t5: moment of the last ground contact of the right foot (third lifting) — photo 37
- t6: moment of the first ground contact of the right foot (third ground contact) — photo 43
- t9: time of the last contact between the hammer grip and the left throwing hand — photo 49

These points of time are the basis of the definition of the movement phases:

- t0 to t2 turn 1 (T1)
- t2 to t4 turn 2 (T2)
- t4 to t6 turn 3 (T3)
- t6 to t9 release phase (R)

Within each of the individual turns we distinguish a double support phase, **tds** (time of double support) — i.e. both feet have ground contact and a single

support phase, **tss** (time of single support) – i.e. only the left leg has ground contact.

3 Time course

The hammer thrower aims to give the hammer a maximal release velocity at an optimal release angle. The magnitude of the optimal release angle cannot be exactly determined, although, depending on the athlete's height and other anthropometric data, the release angle should be as close as possible to the value that is most physically favorable (about 44°). A loss of hammer velocity, which would be caused by a steep attitude angle of the hammer, should be avoided. Table 1 illustrates how Sedykh accomplishes this task.

The release angle of 39.9° is about 4° lower than the optimal release angle. This corresponds to a theoretical loss of distance of about 0.5m. His release height of 1.66m appears to be low, although it is in agreement with the trend to release the hammer at shoulder height (Sedykh is 1.85m tall). The total release velocity is 30.7 m/sec. The velocity curve of the hammer during all three turns and during the release phase is shown in Figure 1.

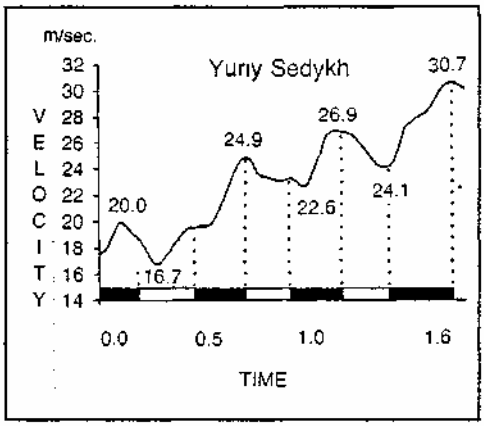

Figure 1: Velocity curve of the hammer (in m/sec.) during the three turns and in the release phase of Sedykh's throw

This brings up the question of how Sedykh achieves these high total hammer velocities, which are clearly above those of other throwers we investigated. In order to answer this question, some selected parameters are presented and explained in the photosequence.

Table 1: Release parameters of Sedykh's World Record throw of 86.74m

Release velocity – total	(m/sec.)	30.7
Release velocity – horizontal	(m/sec.)	23.6
Release velocity – vertical	(m/sec.)	19.7
Release angle	(degrees)	39.9
Release height	(m)	1.66

4 Technique parameters

For the achievement of a high release velocity, a maximal velocity of the unwinding' of the feet is necessary in all turns (and during the last turn in particular). This could he verified by the exact time analysis of Sedykh's world record throw, which was made through the use of the high speed shots (200 frames per second). The photosequence tries to give an impression of the time course of Sedykh's throw (Table 2).

Table 2: Time analysis (in seconds) of Sedykh's world record throw

T1	0.44
tds	0.20
tss	0.24
T2	0.47
tds	0.26
tss	0.21
T3	0.43
tds	0.22
tss	0.21
R	0.27
Sum	1.61

This first analysis shows that Sedykh achieves the shortest total time of the three-turn throwers examined. In the last turn particularly he achieves the lowest values. As far as world-class throwers are concerned, similar results for the last turn can only be found in the 80m throws of some four-turn throwers.

Furthermore, Sedykh, like some other excellent hammer throwers, shows one-legged support phases which are significantly shorter than the two-legged support phases in all three turns. This is possible by reducing the time needed for the one-legged support phases while the time needed for the two- legged support is kept constant. However, the hammer path radius should not be shortened in this process.

Table 3 shows the effects this time distribution has on the length of the hammer path, i.e. the distance the hammer travels in the individual sections of its radius.

Table 3: Length of the distance covered by Sedykh's hammer (in metres)

		Sedykh 86.74m
T1	tds	(3.61)
	tss	3.96
T2	tds	5.15
	tss	4.45
T3	tds	5.18
	tss	4.97
R	tds	6.68
Total		34.10
Ratio of tds to total (t1-t9)		55.80%

One can see that with a ratio of 55.8% between the two-legged support phases and the total turning time (start at photo 11). Sedykh has an extremely long period available for the acceleration of the hammer. Especially in the release phase (photos 43-49). The length of the hammer path of 6.68m for the final acceleration is significantly longer than that of the other throwers, although Sedykh actually ought to be at a disadvantage here because of his anthropometric make-up (arm length).

The cause of this favorable relationship between the two-legged and the one-legged support is the early placement of the trailing leg. This is expressed in the azimuth angle, i.e. the angle describing the position of the hammer in the 360° circle which can be seen in Table 4. (see Samozwetow, 1974),

Table 4: Presentation of Sedykh's azimuth angle (in degrees)

	Sedykh 86.74m
t0	323
t1	90
t2	227
t3	56
t4	216
t5	43
t6	230
t9	101

At the moment of foot lift, Sedykh achieves an average azimuth value of 63°, and at the moment of foot placement his azimuth is 224°. The average length of the acceleration path is therefore 199° (55.3%). This means an extremely long acceleration position during the two-legged stand. According to the definition, Sedykh's foot lift can still be called an early lift, while his foot planting can be called extremely early (according to the definitions of Samozwetow, 1974). There is hardly another hammer thrower who achieves such an early planting position, in particular during the last turn (photo 43) prior to the throw.

A further important part of hammer throwing technique is a lowering of the hip during the one-legged support phase, and a lifting of the centre of the hip during the two-legged support. According to the kinematic analysis, Sedykh achieves his lowest hip height during the first turn in photo 17, during the second turn in photo 30, and during the final turn in photo 42 — which is in each case almost

immediately after the hammer has reached its high point. Photo 9 shows Sedykh's maximal hip height during the first turn, while photos 24 and 36 show his maximal hip height during the second and final turn respectively. In each case this is immediately after the hammer has reached its lowest point. In Table 5, we will have a look at the minimal and maximal values of the heights of the hip centre achieved at these points of time.

Table 5: Sedykh's hip height (in metres)

T1	HH Max HH Min Diff.	0.79 0.69 [0.10]
T2	HH Max HH Min Diff.	0.84 0.70 [0.14]
T3	HH Max HH Min Diff.	0.88 0.68 [0.20]
R	HH Max	0.92

HH Min ..... lowest hip height
HHMax ..... highest hip height
Diff. ..... difference between HH Min and HH Max (lowering)

With 0.69m his average value, Sedykh shows the lowest positions of all throwers. This is true as far as both absolute and relative numbers (comparison with other athletes of equal height) are concerned. This phenomenon cannot merely be due, therefore, to Sedykh's height. Furthermore, in the last turn, Sedykh also shows the most pronounced relative (i.e. in comparison with other hammer throwers) hip lowering with 0.15m and 0.20m on average. The results of our investigation also show that in weaker throws of 80m throwers, and in the evaluated throws of 77m throwers, the relative lowering of the hip is significantly less pronounced. In 70m throwers and in junior throwers even a faulty lift of the hip at the moment when the hammer reaches its high point, and a lowering of the hip at the moment when the hammer reaches its low point, can be observed.

A prerequisite for a deep lowering of the hip is a maximal knee bend of the left leg during the turns, which is especially impressive to look at in photos 15, 29 and 41 where the hammer reaches its highest position. This parameter is independent of the thrower's body height and other anthropometric data. In the positions described, Sedykh achieves his minimal heights (measurement point: rotation axis of the knee joint projected to the ground of the circle) with 0.33m (turn 1). 0.30m (turn 2) and 0.28m (turn 3). Contrary to all other top-level throwers examined, Sedykh achieves his lowest values here. His ability to improve his minimal heights from turn to turn is particularly notable. This extreme body posture and the lowering of his centre of gravity enable Sedykh to achieve an extremely fixed body position and to counteract the pulling force of the hammer.

Apart from these path and time characteristics, the technique of the hammer throw is essentially influenced by the movement of the trunk and the position of the hammer in relation to the shoulder axis. A particularly important technique characteristic is the magnitude of torque. Sedykh shows the greatest torque at t0

and in the turns immediately prior to, or at the moment of, the placement of the right foot (photos 7, 18, 30 and 42). The lowest torque values occur between the moment immediately prior to reaching the zero azimuth angle and the lift of the right foot (photos 10, 23 and 35), as well, obviously, as at the moment of release.

The course of Sedykh's torques is inconsistent with' the trend to build up a maximal torque in the one-legged support phases, which leads to a velocity loss, and to reduce this high torque again in the two-legged support phases, which causes an acceleration of the hammer (Table 6).

Table 6: Sedykh's torque angle (in degrees)

T1	Max	12
	Min	5
	Diff.	[7]
T2	Max	45
	Min	15
	Diff.	[30]
T3	Max	39
	Min	10
	Diff.	[29]
R	Max	41
	Min	−13
	Diff.	[54]

Table 7: Angle between Sedykh's shoulder axis and the hammer wire (in degrees) at selected points of time

	Sedykh 86,74m
t0	[128]
t1	97
t2	93
t3	80
t4	90
t5	86
t6	85
t9	90

In the first turn, Sedykh shows no torque at all, and during the last two turns he achieves values of only 30° of difference between maximal and minimal torque. Contrary to other hammer throwers, Sedykh reduces the magnitude of his torque in favor of a stable trunk position and a more easily controllable body posture. He compensates for this slight trunk torque through an extremely pronounced torque between the hip axis and the imaginary foot axis (connection between left and right malleolus), which at the moment of foot placement is 64° (photo 18), 74° (photo 31) and 68° (photo 43). Particularly as far as the last turn is concerned, this is the highest value we measured.

Table 7 shows the angle between the shoulder axis and hammer wire at defined points of time. This angle is 90° when the hammer is immediately in front of the body. If the hammer is "dragged", the angle increases (up to 150°) — a "lead" of the hammer results in values below 90°.

Even here Sedykh tries to take a very fixed position and to let the hammer lead or drag as little as possible. As far as this is concerned, he succeeds particularly well at the important points of time mentioned above; showing values between 85° and 97°, and even the extreme values are only between 78° and 115°. By the way, the throwers from the German University for Sports examined by us were the only ones to show a lead of the hammer. Other athletes show trail values of the hammer of up to 150° and show no lead of the hammer in any phase of the total movement.

5 Implications for hammer throw technique and training

The results of the kinematic analysis of Sedykh and the comparison with other hammer throwers show the following trends as far as the technique and thus the training of the hammer thrower is concerned.

The factor most responsible for a great throwing distance is the magnitude of release velocity. Compared to this, release height and angle can be neglected. Athletes whose body height is below 1.85m achieved release angles of maximally 40° in their best attempts.

The hammer thrower achieves a maximally high release velocity through an optimally executed unwinding of the feet during the turns. Here the one-legged support phase should be shorter than the two-legged support phase, especially in the last turn. This is achieved by a lifting of the right foot at an azimuth of about 65° and a placement of this foot as early as possible at a constant angle of 220°-230°.

In order to maintain a high velocity during the turns, a maximal lowering of the body at the time of the high point of the hammer path is necessary. Furthermore, a maximal knee bend is necessary in order to counteract the pulling force of the hammer, without, however, giving up the vertical trunk position, as a countermovement of the trunk would automatically lead to a performance-reducing shortening of the radius.

In particular, Sedykh's technique shows that a maximal velocity of the hammer is achieved through a "thrower-hammer" system which is as fixed as possible. Trunk torques of maximally 30°-40° and a constant hammer position of about 90° between shoulder axis and hammer wire with a slight lead or following of the hammer make significantly higher turning velocities possible. The acceleration of the hammer is produced by the build-up and unwinding of the torque between the feet and the hip axis, which at the moment of foot placement, shows values of about 70°.

Development of the technique criteria mentioned should take place as soon as possible in the training of a hammer thrower, i.e. it should be a part even of beginner training. In particular, it is essential that the correct lowering and knee bending behavior as well as the position of the hammer in relation to the thrower is emphasized right from the beginning since it is extremely difficult to alter a faulty technique later on.

Photosequence

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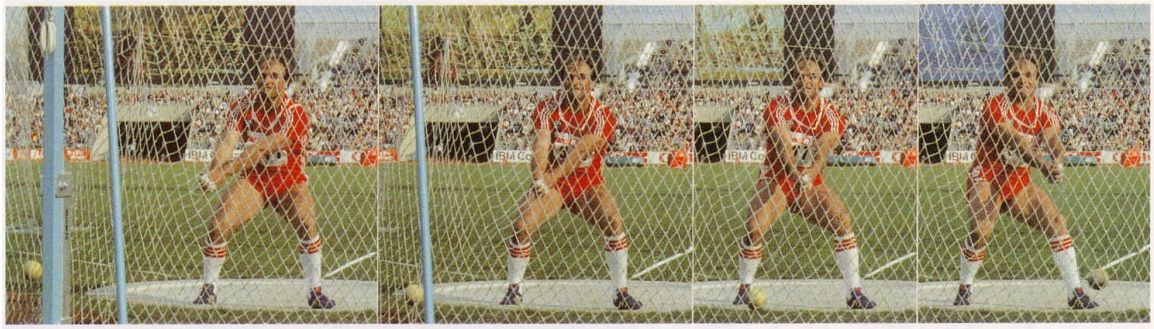

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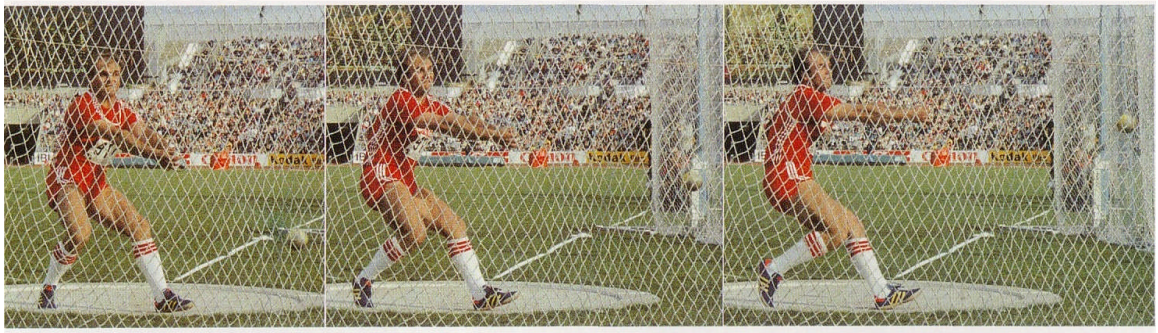

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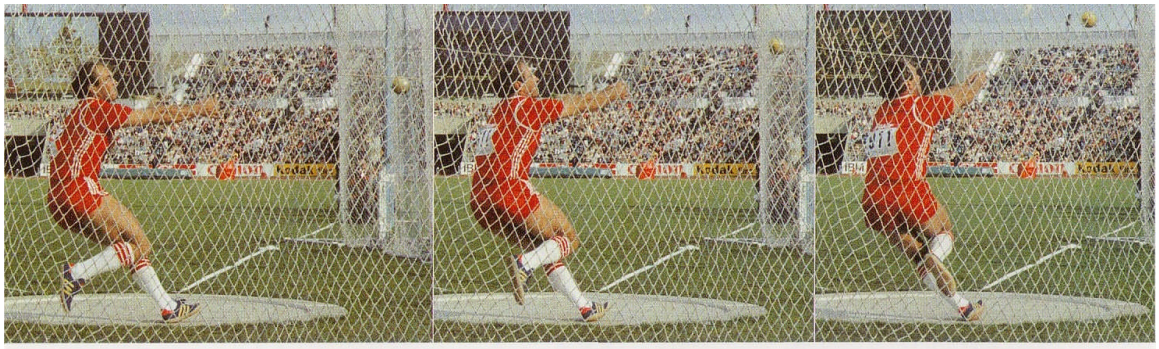

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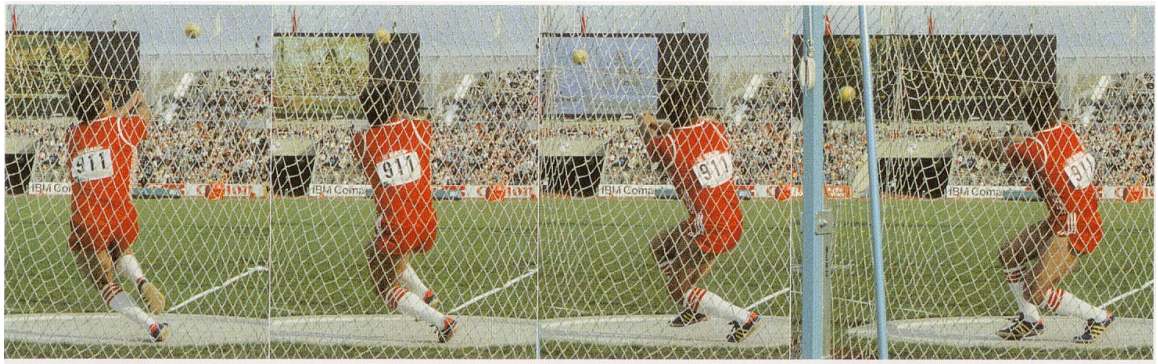

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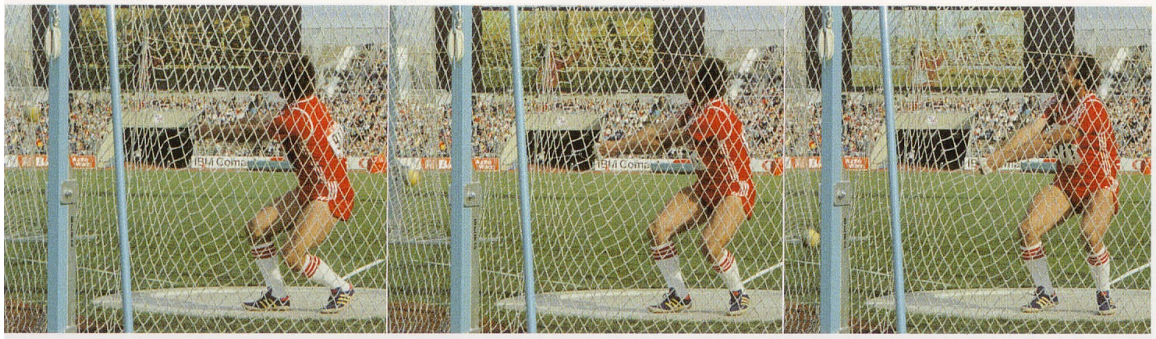

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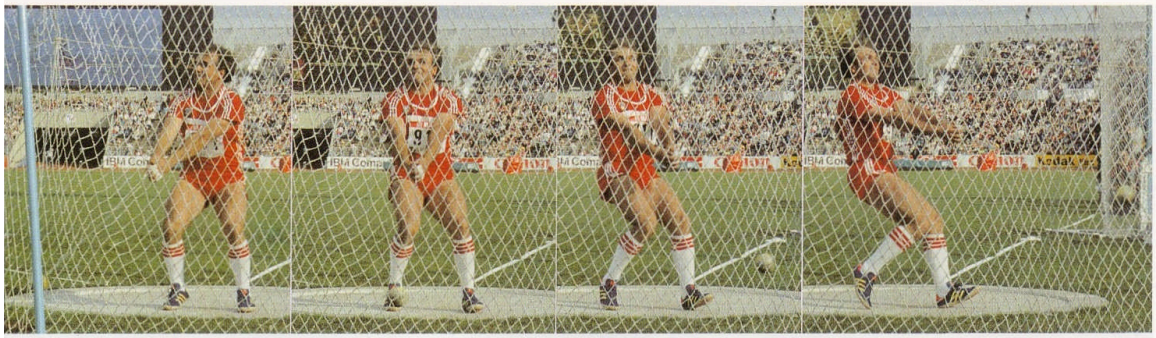

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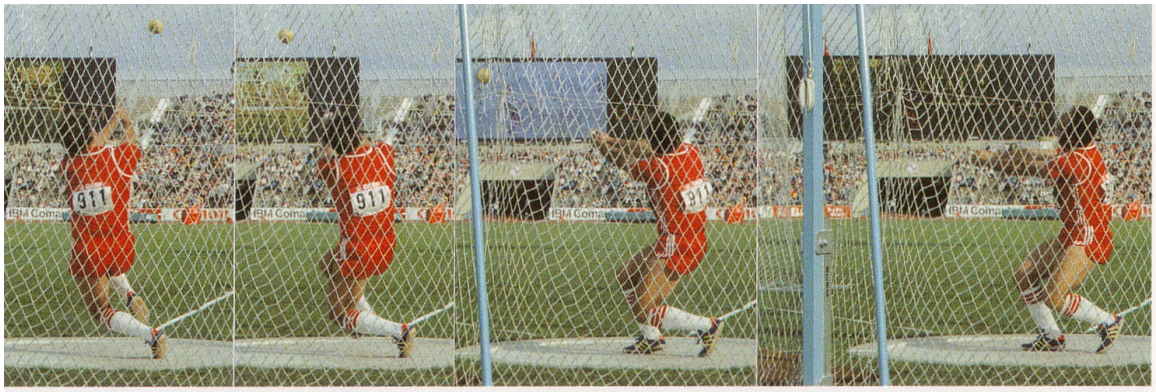
26 27 28



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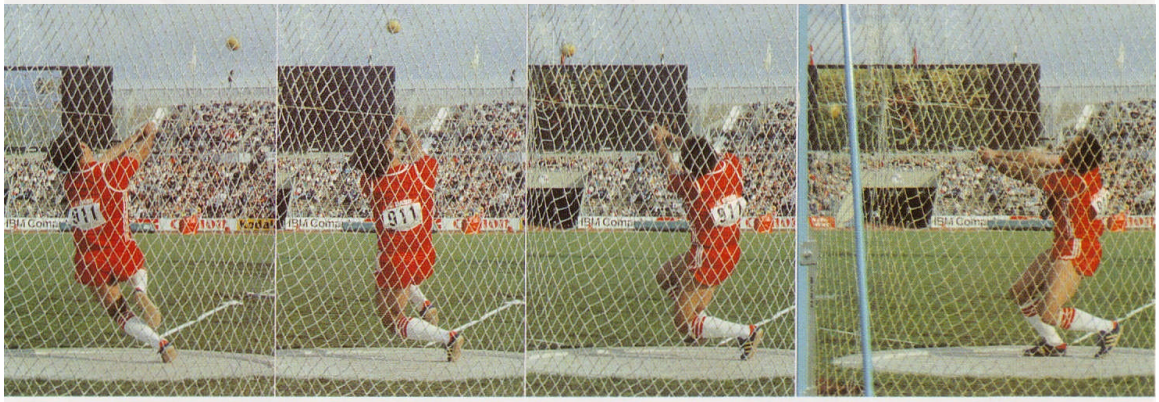

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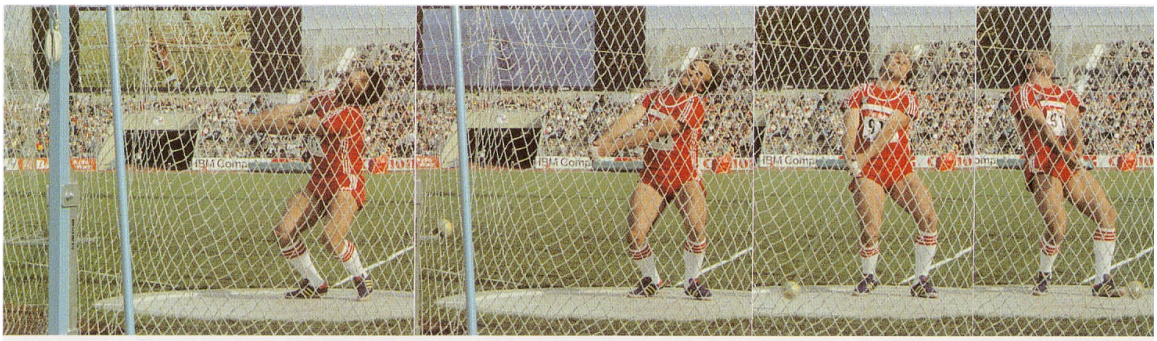

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